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AUTHOR Sage, Morley; Smith, David J.
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ABSTRACT

Prepared to advise the Social Science Research Council, this report suggests funding priorities for a program of research in the field of educational applications of information technology, with special reference to the primary and secondary sectors. A discussion of the research program initiative context includes the contributions of governmental and government-supported agencies, research and development efforts in North America, and economic considerations. An examination of the need for research on new technology emphasizes its importance for providing an information base for curriculum design and a research base for the "education industry." Attention is drawn to the current lack of focus and direction in United Kingdom research and the increased risk of dissipation of effort created by a shortage of funds. Two research emphases are proposed: learning processes and information technology, and curriculum and the information society. Potential research problems are considered, and detailed outlines are provided for recommended programs of commissioned research. Fifty-eight references are listed. (Author/LMM)

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A consultative document for the SSRC Education and
Human Development Committee

Microcomputers in Education

A Framework for Research

Morley Sage
David J Smith



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PREFACE

by Professor Philip Levy

Chairman, SSRC Education and Human Development Committee

The Education and Human Development Committee of the SSRC received and gave preliminary consideration to this report in April 1983. As a first step the Committee decided that the report should be given wide and speedy distribution as a consultative document. We anticipate that a workshop will be arranged later in the year to discuss reactions to the report and to consider ways in which we might proceed.

The report draws attention inter alia to strategic weaknesses in UK preparedness for 'Information Technology in Education'. The UK is not, of course, alone in this respect. It is obvious that there is no lack of issues to be researched: the report refers, for example, to 'theoretical impoverishment'. It is my personal guess, however, that as much attention needs to be paid to the management and organisation of a research programme as to the specific studies that many of us will be tempted to propose.

Comments on the report are invited and should be addressed to:

The Secretary

Education and Human Development Committee

Social Science Research Council

1 Temple Avenue

London EC4Y 0BD

to arrive not later than 30 September 1983

June, 1983

MICROCOMPUTERS IN EDUCATION

A Framework for Research

by

M W Sage (Director)

D J Smith (Research Fellow)

of

The Computing Service

University of Southampton

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community

0. INTRODUCTION

0.1 In April 1981, an SSRC Working Group under the Chairmanship of Dr P Clarke, Principal of Robert Gordon's Institute of Technology, proposed a research programme on "The use and application of microelectronics technology in education". The council of SSRC subsequently took note of the Working Group's conclusion that a programme should be constructed following a commissioned study and approved in principle a five-year programme of work.

0.2 A contract was awarded to Morley Sage, Director of the Computing Service, University of Southampton, to construct a detailed research programme appropriate to the SSRC (of up to £500,000) in the light of a research review and of the activities of other government agencies. A research fellow, David Smith, was appointed in May 1982, and the work on which this report is based commenced forthwith.

0.3 An Advisory Committee was established to assist in the formulation of the programme of research. The members of this committee are:

Professor P Kelly, Faculty of Education, University of Southampton;

Professor H Francis, University of London Institute of Education;

Mr G Hubbard, Director, The Council for Educational Technology;

Dr J Howe, Department of Artificial Intelligence, University of Edinburgh;

Mr C Sweeten, Director, ISMEC, Westminster College, Oxford.

The members of this team have been able to bring considerable experience in educational practice and research, in areas such as teaching, curriculum development and evaluation, psychology and artificial intelligence, to bear on the critical appraisal of our recommendations.

0.4 This report is endorsed by the Advisory Committee, who also accepted an early decision to broaden the scope of the proposed initiative from simply "Microcomputers in Education" to include relevant aspects of Information Technology (IT).

1.1 Context

- 1.1.1 This initiative takes place in a climate of rapid social and technological change, and of consequent concern by a variety of governmental and government-supported agencies. The contributions of these agencies and their relationships to the present proposed initiative are discussed.
- 1.1.2 The significance of research and development efforts in North America is reviewed on the basis of literature searches and a study visit to Canada and the USA made in June 1982. There are many valuable lessons to be learned from US experience, not only with the application of computers in education but also with the management and organisation of research.
- 1.1.3 The economic context of the initiative is considered. The large percentage of GNP devoted to education is emphasised, and attention is drawn to the potential future significance for the UK economy of an international market in traded educational services. The importance of research for this "education industry" is stressed.

1.2 The Need for Research

- 1.2.1 The potential impact of IT on the school curriculum is discussed in the light of probable social and economic developments over the next two decades or so. The need for a more process-centred curriculum is anticipated. This need is seen as being exacerbated rather than caused by the advent of IT. It is argued that many of the pressures on education due to the effects of IT result as much from the pace of change as from the fact of change.
- 1.2.2 New technology is seen as offering teachers powerful tools for the design and organisation of learning experiences, as well as providing a source of conceptual models of the processes and strategies of learning.
- 1.2.3 The part played by the UK teaching profession in the recent rapid expansion of educational computer usage is acknowledged, but it is concluded that much recent development has taken place in the absence of substantial research. Attention is drawn to the lack of a formal basis for the design of learning experiences based on the use of IT devices - a situation described as "theoretical impoverishment".
- 1.2.4 It appears critically important that the full spectrum of learning experiences potentially available through the application of new technologies should be exploited as fully, as effectively and as soon as possible. This exploitation requires a substantial information base and a framework of models of learning, teaching and the organisation of knowledge. These requirements can only be met by a great deal of research.

- 1.2.5 It is argued that research is needed to meet two particular areas of need:

an information base for the design of curriculum

a research base for the "education industry"

1.3 A Framework for Research

- 1.3.1 Attention is drawn to the lack of focus and direction within the UK research community in this context. There is much risk of dissipation of effort, the more so because of the inadequacy of the funds available to this initiative. A policy of commissioning a limited number of research projects addressed to a coherent theme is advocated.

- 1.3.2 It is argued that the fundamental need is for research which will contribute to the information base and theoretical models which will inform the design and implementation of learning experiences based on IT applications in a variety of contexts. On the basis of past experiences with curriculum development and dissemination, it is also suggested that there is a need for understanding of management structures and information systems within education.

- 1.3.3 Two research thrusts are proposed:

Learning Processes and Information Technology

Curriculum and the Information Society

The first of these programme titles would be directed towards the styles, strategies and processes of learning with IT. The second programme would be concerned with the effects of the technology on and in the curriculum, and with formal and informal systems through which information and knowledge are transmitted within, into and out of the educational system.

- 1.3.4 These research programmes will demand a high degree of multidisciplinary collaboration. This might be expected to lead to fruitful synergies and eventually to new insights into the nature of the problems being tackled.
- 1.3.5 There is a strong case for the establishment of a Technology Centre, inter alia dedicated to multidisciplinary research into aspects of the educational significance of IT, with particular emphasis on the principles underlying the design and implementation of technology-aided learning experiences.
- 1.3.6 It is pointed out that there are many points of convergence between research priorities identified in this study and the long-term strategic objectives for AIT (Advanced Information Technology) identified by the Alvey Committee. It is argued that the funding possibilities inherent in this convergence should be explored.

1.4 Potential Research Problems

- 1.4.1 The complexity of the problems to be investigated is discussed, and the need to consider new methodological paradigms is stated. In particular, the importance of accepting hitherto disregarded or apparently unorthodox research designs is asserted.
- 1.4.2 Great stress is laid on the need for researchers to give attention to communication with the broadest possible audience. It is argued that failure to communicate may be disastrous in the present climate of financial austerity and hostility to the social science research perspective.
- 1.4.3 A number of potential problem areas under the two programme titles are outlined and discussed. In addition, a number of "watching briefs" are described. These are projects or developments initiated by agencies other than SSRC, but where the attention of the Council might become appropriate in due course. Involvement and initiative could profitably form an activity for the proposed Technology Centre.
- 1.4.4 Constant attention is drawn to opportunities for the collaborative funding and initiation of research, with special reference to the conclusions of the Alvey Committee.

1.5 Research Proposals

Learning Processes and Information Technology

- 1.5.1 It is argued that research in this context should be focussed on the future, rather than the present. In particular, it is proposed that the Council should support research under this title which will relate to a demand for courseware which reacts 'intelligently' to the needs of individual learners.
- 1.5.2 It is believed that the first priority in this respect is for research directed towards models of learning processes and the organisation of knowledge applicable to the design of educational experiences and understanding of the needs of learners. It is argued that this is a fundamental need of education irrespective of the level of technology deployed.
- 1.5.3 It is proposed that research be initiated within a framework directed towards computational modelling* of learning processes. Attention is drawn to the high cost and inherent difficulty of this approach, but these are argued to be justified by the probable payoff in terms of knowledge and understanding.

* In computational modelling, attempts are made to develop computer-based systems which perform the desired activity to a specified level of effectiveness. The construction of such systems is a valuable tool for developing understanding of many cognitive processes (See for example Winston, 1971; Fischer 1981).

- 1.5.4 Further research under this title should be directed towards the establishment of 'archival' baselines against which the effects on young children of growing up in a computer-rich culture might be measured. It is suggested that whereas this research is not so formally important as the computational modelling initiative, the rapid changes in society which are now apparent will mean that there will soon be no further opportunity to study these effects. At a lower level of priority, it is suggested that studies of the social effects of IT be initiated.

Curriculum and the Information Society

- 1.5.5 This research should be directed towards the efficient management of changes in educational practice and organisation. We need to advance to a model of organisational change which will permit curriculum developers to operate effectively in the future.
- 1.5.6 A number of research projects are advocated. In some cases estimates of effort required in man-years are given. It is presumed that in many cases there will be implicit parallel funding by the institutions to which the grants are awarded.

1.6 Recommendations

- 1.6.1 It is proposed that specific initiatives be commissioned under the aegis of the above programme titles:

Learning Processes and Information Technology

1. For Immediate Implementation

- a. A major initiative directed towards computational modelling of learning and cognitive processes, with the long-term objectives of providing bases for the design of learning experiences based on the next generation of IT devices.
- b. A study to provide baseline data for future research into the effects of IT on young children's thinking.

2. For Eventual Implementation

Classroom observation studies of the effects of IT on social interactions in schools.

Curriculum and the Information Society

3. For Immediate Implementation

- a. A series of linked case studies to investigate the factors which promote or inhibit the uptake of new technology and its applications by schools.

4. For Eventual Implementation

- a. A study of management strategies in the introduction of IT in education.
- b. A cluster of case studies of highly resourced schools to observe styles of IT usage and their effectiveness.
- c. A study of the role of special interest groups in curriculum innovation.
- d. The impact of industrial and commercial automation on the content and organisation of school curricula.
- e. The effects of courseware styles on school curricula. (This study would depend on analytic models from the major initiative on computational modelling, and so could not be implemented immediately).

2. THE CONTEXT OF THIS REPORT

2.1 SSRC has been concerned for a number of years with research into the potential role of computers and related technologies in education. However, although the Council has supported a number of significant studies in the past, it was not until the Working Group on Microcomputers in Schools commenced its activities late in 1979 that the Council's concern became well articulated. It was both coincidental and fortuitous that at this time a number of influential factors emerged which resulted in major government initiatives. The deliberations of the Working Group (and, to a lesser extent the production of this report) took place against a background of rapid change. This change was not merely technological but involved rapid adjustments in society and (possibly more importantly) in public opinion and awareness. It is important that these "external factors" should be fully recognised when considering the importance of the recommendations made in this report.

2.2 The principle 'milestone events' relevant to considerations of the role of IT in education are:

- The £9,000,000 DES support for the Microelectronics Education Programme (MEP) - recently extended for a further period at an additional cost of £9M.
- The SED commitment to the Scottish Microelectronics Development Programme (SMDP).
- The DOI Micros in Secondary Schools Programme, and its recent extensions, particularly to primary schools.
- The Fifth Generation Computer Conference and the prospect of Anglo-Japanese collaboration.
- The Report of the Alvey Committee.
- The British Telecom liberalisation programme.
- The government's 'Cable Initiative' and the reports of the Hunt and Eden Committees.

The milestones listed above need to be considered in turn against the recommendations of this report and their relevance to the directions advocated for research and development in IT in Education.

2.3 The Microelectronics Education Programme

2.3.1 Some of the original aims of the programme were outlined in Parliament by Mr Neil MacFarlane when he said that it "... will serve the needs of education by helping schools and colleges to make better use of microelectronics as a teaching resource and to equip young people with the skills which are required to exploit the economic potential of the new technology. Much innovation is already taking place and the new programme will only be successful if local education authorities take up the ideas and activities which prove successful". (Hansard, 4.3. 1980 : oral reply).

- 2.3.2 In a subsequent strategy paper (Fothergill, 1981), the Director of the MEP stated that the aim of the programme was to help schools prepare children for life in a society in which devices and systems based on microelectronics were commonplace and pervasive. People would need to be aware that the speed of change was accelerating and that their future careers might well include many retraining stages as they adjusted to new technological developments. The strategy programme then went on to stress three dominant themes:

Curriculum development - with the emphasis on the development of both traditional and new topics

Teacher Training - familiarisation with microelectronics and the acquisition of 'computing' skills

Regional resource organisation and support - the establishment of Regional Information Centres (RIC's), and special emphasis on the role of the Council for Educational Technology

2.4 The Scottish Microelectronics Development Programme

- 2.4.1 This programme was conceived somewhat differently from the MEP, with the special needs of the Scottish Educational Department in mind. An essential difference is that it is a centralised agency, designed to develop in stages (it is now in phase 2 of its development programme). SMDP is established as a long-term entity, as opposed to the fixed term of MEP, though some doubt has recently been shed on its effectiveness (Odor and Entwistle, 1982).

- 2.4.2 The principle objectives of SKDP may be summarised as:

The development of general awareness and understanding of microelectronics among staff and students

The development of curricula and curriculum materials and their dissemination

The application of microcomputers to management in schools (the SCAMP project)

The exploitation of microelectronics for special education needs

The development of ways and means of promoting joint industry and education microelectronics projects in association with the Microelectronics Educational Development Centre (MEDC)

2.5 The Department of Industry's Initiatives

- 2.5.1 These schemes were intended to be enabling initiatives through the supportive provision of equipment, firstly to the secondary sector and then subsequently to the primary sector. Each benefitting school has been required to release two teachers for training. This training, which

was not provided by the DOI, has inevitably been concerned with technological familiarisation, and not to any great extent with curricular issues.

- 2.6 The above programmes have all been concerned with the injection of technology into the educational scene, the means by which it can be used quickly and the development of educational materials. In the latter context, the technology has been applied in a manner which to a large extent simulates traditional methods and practices. None of these programmes has been concerned with fundamental educational issues or the development of that understanding which is so essential to the successful utilisation of any new technology within education and the appropriate evolution of the curriculum.

2.7 Alvey and the Fifth Generation

- 2.7.1 The Alvey Committee was set up largely as a result of the Japanese Fifth Generation Computer Programme, to advise the Minister for Industry and Information Technology on the potential for collaborative research programmes in Advanced Information Technology (AIT) and to make appropriate recommendations. The committee identified four "Enabling Technologies":

Very Large Scale Integration (VLSI)

Software Engineering

Man-Machine Interfaces (MMI)

Intelligent Knowledge-Based Systems (IKBS)

The last two, namely MMI and IKBS, are specially relevant to this report, though the comments made by the Alvey Committee with regard to the high international standing of British software might also be taken into account. The main focus of attention in the Alvey report was on technological developments, and although attention was directed towards the significance of understanding of cognitive processes and the organisation of knowledge for the design of expert systems, relatively little attention was given at the enormous potential value of this understanding for the evolution of education.

2.8 The Cable Initiatives

- 2.8.1 The government is proposing to introduce wide band-width communication facilities which should be accessible to all homes and communities. One aspect of this initiative is the development of Cable TV (which was the particular interest of the Hunt Committee), but it also includes the provision of interactive communication facilities involving both digital and video data.
- 2.8.2 Although the provision of Cable systems might take many years, the fact that it will come must be taken into account when considering the potential role of IT in education. For instance, the role of distance learning in formal education could change quite dramatically, and IT

devices could provide additional learning opportunities as significant as those currently presented by the microcomputer.

2.8.3 It is axiomatic that the educational community must be fully aware of the potential significance of these developments, and must be securely placed to exploit them early and effectively, and without further chaos which surrounded the advent of the microcomputer in education.

2.9 Most initiatives in this field which have been primarily educational in orientation have been concerned with:

bringing about IT awareness within schools (see DES draft discussion paper "Information Technology in the 11-16 Curriculum", 1982)

the application of existing technology and the dissemination of skills in its use

the development of software (generally within the teaching community) to augment current teaching practice

the use of specific CAL and CAI techniques as modes of IT application in the teaching of specific subjects

Some research has been supported (for example, Elder, Wills, Johnstone and Gourlay, 1982), but little or no attention has been given to the need for a fundamental understanding of learning, cognitive processes and the organisation of knowledge. Such understanding is essential to the design of learning experiences based on IT applications. Indeed, the question of what is called "Instructional Design" in the USA has been largely ignored in British initiatives, and design considerations, at least within the initiatives referred to above, appear to have been restricted to ad-hoc formulations of software style rules based on practical experience and practitioner lore.

The North American Perspective

2.10 Although there is a long history of research in the field of educational computing in the UK, the active community has always been rather small. The Working Group drew attention to the need for research and the diffuseness of effort and lack of direction within the research community which existed at that time. Bearing this in mind, we took the view that the experience of the North American research community might be relevant to our search for tractable research problems. The greater size of the community, particularly in the USA, seemed to suggest that a greater range of problems would have been tackled than in the UK, and that promising avenues for development would have been identified and opened up. Unfortunately, however, extensive literature searches proved fruitless, and it became clear that personal contact with active researchers would be necessary before any evaluation of US research efforts could be attempted. Accordingly a study visit was made to the USA and Canada in June 1982.

2.11 The visit to North America proved to be very valuable. It became evident that, whilst there was indeed a far greater intensity of research effort there than in the UK, the

productivity of that effort was generally rather low and in many cases distinctly unimpressive. In particular, it was found that the computer had re-awakened the programmed learning movement, and that a good percentage of the research effort was directed towards justification of rather simplistically behaviourist CAI materials in terms of "cognitive gains". More interest was expressed in the capacity of computers and related devices to induce gains in scores on standardised tests than in the potential value of the technology in supporting new styles of learning. Nevertheless, the extent of the interest shown by practicing teachers in LOGO and similar environments was impressive: an interest which, it must be said, has subsequently been mirrored in this country.

- 2.12 It cannot be denied that much impressive research has been carried out within the field of educational computer application both in the USA and (to a lesser extent) Canada. A greater awareness of the need for sound models of learning and cognitive processes to support the design and implementation of educational experiences was found in those countries than in the UK, and less tendency on the part of practitioners to dismiss theoretical considerations as irrelevant to classroom practice.
- 2.13 Fundamental research in the USA has been inhibited both by recent changes in government policy towards funding and by a long-established trend towards entrepreneurial exploitation of research which often led to the abandonment of very promising long-term research as soon as marketable products appeared to be emerging. Whether this is an entrenched side-effect of the US academic tenure structure, or simply a sign of the times (*omnis Romae venialia!*) was not clear, but it was a cause for some concern among US universities, who find themselves increasingly reaping neither financial nor intellectual benefits from their support for research. Clearly it will be necessary for the relationship between basic research and commercial product development to be considered very carefully in the UK context.
- 2.14 There are many valuable lessons to be learned from US experience, not only with applications of computers in education, but also with the management and organisation of research. There seems little doubt that we are set to repeat many of the mistakes already made within the US research community. There is little harm if in re-inventing the wheel we are able to discover a better axle, but there is a very clear case for international collaboration and co-operation to minimise unproductive duplication of effort.

The Social Perspective

- 2.15 A final element to be considered in the context of this report is the rapid social change which is now taking place. As the focus of economic activity moves away from factories and offices into new environments, such as the home, political (in the deepest sense) pressures will arise for changes in the emphasis of education. Preparation for activity in a 'work' environment might need to give way to preparation for activity in a predominantly 'leisure' environment which nevertheless includes certain 'work' elements. The trend away from the constraints of the office and factory towards self-supervision will greatly influence our ideas about personal development. Modern IT could play an enormous role in this move from dependence to independence

in learning. Similarly, as adjustments occur in the balance between pre-and post-work education, the role of IT might be expected to increase in importance. In view of the vast proportion of GNP which is concerned with education, these changes may be of very great economic significance, and indeed, it becomes realistic to speak in terms of an 'education industry'. This report is, to a very large extent, concerned with the research and development base for this industry.

3. THE NEED FOR RESEARCH

3.1 It is considered that research in this field must meet two particular areas of need:

- . An information base for the planning of curricula.
- . A research base for what might be called the "Education Industry"

Some of the pressures which arise from these areas of need will be considered in this section.

Information Technology and the Curriculum

3.2 Computers and related devices will have profound effects on society during the remaining years of the present century. As society adapts, perhaps painfully, to new circumstances, changes will occur which will inevitably have complex effects on our thinking about education. At the same time, advances in technology will both influence our ideas about the school curriculum* and shape the ways in which those ideas may be implemented. Technology will thus have effects both ON the curriculum and IN the curriculum. Research which will contribute to our understanding of these effects and of the issues surrounding the development of curricula for the era of rapid change into which we are now moving must be given a high priority.

The Information Society

3.3 It is quite impossible to predict the future with any certainty, but there is (fortunately) a certain consensus of opinion about the probable impact of IT on society during the next few decades (see for example, Gosling, 1981; Curnow, 1980; Peltu, 1981). The discussion of this report is based on this consensus view, some features of which will be outlined below.

3.4 A shift of emphasis towards the manipulation of information rather than material artifacts is already an established feature of the working environment for many people, and current trends in this respect may confidently be expected to continue for some time to come (Bell, 1980). In addition, the Alvey Report (1982) stressed the economic significance of IT, putting the numbers then employed in the UK industry at about 900,000. We may plausibly extrapolate from the present situation to a point where most routine clerical data control operations are automated to some extent, and where the bulk of non-archival routine information is stored on electronic media (though printed books will remain cost-effective for certain data-storage applications into the foreseeable future).

* The term 'curriculum' will be used here and elsewhere in this report to refer to the total intended educational experience of the learner, whether formal or informal, 'hidden' or explicit. It will not be used to denote any specific corpus of methodology or subject content.

- 3.5 A range of computer databases are becoming the foci for a burgeoning variety of knowledge-based economic activities. In the future, access to these databases and the computing power which is associated with them will not be restricted to conventional offices or production units, and, as has already been suggested, the home could become the normal workplace for a large percentage of the economically active population. This dispersal of the workforce will lead to a reduction in the significance of middle management supervisory functions which do not contribute directly to added value. Workers will thus gain autonomy and responsibility, especially in relation to quality control and productivity, but also in relation to the organisation of work schedules. Group social integrity and information flow will be maintained through various electronic media.
- 3.6 Specialised skills and knowledge will be increasingly short-lived, so that periodic updating and/or retraining will become normal and necessary features of working life for the majority of people, rather than for a small minority as at present. Knowledge-based expert systems will relieve many specialist workers of the need to memorise a mass of facts, case knowledge, technical detail and so on. Consequently, many people whose minds are today thus encumbered could be freed for imaginative thinking and creative problem-solving in the course of their everyday work. The pace of economic, social and political evolution will be accelerated as a result of the release of all this creative energy, and goods, services, processes and even whole industries will arise, flourish and decline at a hitherto undreamt-of rate. Great flexibility of labour will be demanded, and it will be facilitated by the availability of intelligent computer-based training systems.
- 3.9 Pressures on the curriculum, do not, however, result directly from the impact of computer-based technologies, but reflect instead the dynamic nature of the relationship between the needs of society and the products and processes of education. The advent of the microprocessor may indeed have served to concentrate our minds wonderfully, but many of the issues which it has forced into our consciousness are long-standing problems, related to the ways in which educational systems respond to economic and social change. It is the pace of change, rather than the simple fact of change which is the particular contribution of modern technology to these problems.
- 3.10 Despite this fact, however, there are undeniably pressures on school curricula to adapt in response to such factors as the projected manpower requirements of the information society. Some schools have reacted to such pressures by assimilating new subjects such as Control Technology, Electronics and Computer Studies into their curricula. The term "Computer Literacy" has been used to describe this broad area of instrumental concern. There appears, however, to be little consensus as to the precise meaning of "computer literacy", and interpretations cover a gradation of content, from generalised "computer awareness" to specialised "computer science" (see Seidel, Anderson and Hunter, 1982). It is difficult to see how the unplanned accretion of small amounts of new material onto otherwise unmodified conventional curricula can serve any useful purpose, and the Alvey Report was indeed rather critical of such approaches. Ad hoc adjustment cannot provide adequate grounding for the educational requirements of a radically changed society or for the clearly

unpredictable needs of still undeveloped industries. Notwithstanding these reservations, it would appear that much useful critical consideration of school curricula has been stimulated by consideration of the demands for future working environments, but little of this thinking has yet been organised (though see Masterton and McCormick, 1982; Maddison, 1983).

- 3.11 Setting aside pressures on the curriculum arising from the needs of industry and commerce, note must be taken of the 'professional' pressures arising from teachers' perceptions of the educational value of new technologies. Technology offers teachers opportunities to extend the power, range and effectiveness of the human intellect. Computer-based devices provide powerful tools for the design and organisation of learning experiences, both directly, through their potential as learning aids, and indirectly through their role as sources of conceptual models of the processes and strategies of learning. It is fast becoming possible to conceive and develop new teaching techniques and learning environments, by means of which educational goals may be attained which have long been considered desirable, but which were hitherto beyond our grasp. This must inevitably influence our ideas about what may be attempted in the course of education, and by whom and at what age.

The effects of IT in the curriculum

- 3.12 It has been argued (Smith and Sage, 1983; Watt, 1982) that 'computer literacy' should be regarded essentially as a cultural phenomenon, emerging from the total curricular experience of the individual and best developed through contact with routine application of modern IT in as many educational contexts and roles as possible. At first this may appear to be simply the rationalisation of a technology-led search for applications of devices simply because they exist. 'Technology-Push' is, of course, an important factor here as elsewhere, but our feeling is that the interests of learners are best served by the planned realisation of the potential inherent in IT for the attainment of aims and objectives which are fundamental to education.
- 3.13 The range of applications for IT in education (summed up by Taylor, 1980, as "Tutor, Tool, Tutes") is quite enormous, perhaps limited only by the human imagination. This fact appears to be generally perceived, albeit in a rather vague and uncritical sense. There is an unfortunate tendency to cast the computer in the role of 'deus ex machina', waiting in the wings to come to the rescue of an ailing educational system, and there are dangers in such attitudes. Hooper (1978a) pointed out that the early adoption of computers in education had been hindered by over-ambitious claims for the technology. At the other extreme, Sheingold et al (1981) revealed a situation in parts of the USA where computers were used to deliver stultifyingly unimaginative, ill-conceived and badly implemented curricula. Howe and DuBoulay (1979) were quite right in our opinion to point out that modern technology can be used as easily to turn the clock backwards as to advance it. Modern IT has great potential value for education, but without clear insight and understanding about what might be achieved, there is much danger that this potential will not be realised and that instead the capacity of modern technology for human intellectual emancipation will be dissipated for many years.

- 3.14 The extent to which the British teaching profession has risen to face the challenge of the new technologies could hardly have been anticipated only a few years ago. Hubbard (1981) reported that in 1980 there were just over 700 microcomputers in British schools chiefly used in computer studies and mathematics. (A survey in the same year in the USA by Goor, Melmed and Farris, 1981 revealed more than 30,000 microcomputers available for school use.) Thanks in some large measure to the initiatives taken by the government through the DOI programme for subsidising schools' purchases of computers, the situation in Britain has improved dramatically, though we are still a very long way behind the USA, at least in levels of hardware provision. As Becker (1982) argued for the USA, a very high and sustained level of capital investment will be needed to achieve the "critical mass" necessary to bring about major changes in classroom practice. Nevertheless, progress is undoubtedly rapid, and indeed educational practice may be said to be evolving almost too fast for new developments to be widely disseminated and assimilated before they are outmoded. Almost all of this activity may, however, be characterised as 'innovation without research', based on professional intuition and personal insight, rather than on substantial research. A great wealth of expertise has been amassed within the teaching profession, but the bulk of it is not supported by a systematic information base or by any depth of theoretical understanding. It must indeed be observed that this deficiency is not widely recognised within the teaching profession in the UK, which retains a remarkable propensity for intellectual "luddism".
- 3.15 As teachers have acquired expertise in the use of the computer, the programming and coding of software have become increasingly elegant, but this apparent sophistication may disguise fundamental inadequacies in the design of the materials (Self, 1982). The continuing absence of a theoretical rationale for the design and implementation of IT-based educational materials and learning environments has led to a situation where much currently available courseware is based on naive concepts of the process of learning and the organisation of knowledge. For the most part (there are important exceptions), the production of educational materials remains a "cottage industry", devoid of an adequate design base.
- 3.16 To speak of theoretical impoverishment is not to belittle the practical value of much of the present corpus of 'practitioner lore' and 'clinical' case knowledge, far less the pioneering spirit and enthusiasm which led to its acquisition. Nevertheless, this impoverishment could be a significant obstacle to the evolution of the curriculum in the face of the pressures alluded to earlier. Revolutionary upheavals aside, the curriculum with which we face the future will develop from present-day practice, structures and experience, yet there is a great deal about these which is understood only poorly, if at all. There is no secure foundation of theory or even a hardcore of information on which future developments may be built. We have only the most inadequate basis for the design of the curriculum or of educational experiences within its framework. The provision of underpinning for curriculum development through appropriate research is therefore a matter of great importance.

- 3.17 Gutenberg's information technology revolution took place 500 years ago, yet even today many teachers apparently lack the skills and techniques needed to help children to use printed works to best advantage (Schools Council Curriculum Bulletin 9). We cannot afford to spend centuries or even decades groping blindly for the key to effective educational use of computer-based IT. It is quite crucially important to children, young people and society in general that the full spectrum of learning experiences which are potentially available through the use of the new technologies should be exploited as soon and as effectively as possible. This exploitation requires a substantial information base and an adequate framework of models of learning, teaching and the organisation of knowledge to which this base may be related. It is these urgent needs which must be met by research.

The Education Industry

- 3.18 As de-industrialisation proceeds, there is a growing realisation that our future economic well-being will depend on the development and exploitation of knowledge-based high-technology, high-added-value industries and services. Education and educational services should be regarded as knowledge-based services with potentially world-wide markets, and the role for IT-based materials within this market is obviously likely to be very great. Commercial considerations should not become dominant in the context of this initiative, but it is important that the appropriate degree of attention should be given to these matters.
- 3.19 It is possible to foresee a situation in which both business corporations and government agencies are clients for "custom-designed" education and training systems. The design of education systems and materials will demand a sound research base, and the implementation of such systems will require much practical experience in a variety of contexts. Therefore it is envisaged that a major research initiative now would form the basis for the research and development platform of a potentially important area of future economic activity.

4. A FRAMEWORK FOR RESEARCH

- 4.1 The technological 'quantum leap' which brought stand-alone microcomputers within the financial reach of most schools has sharply highlighted the defects and deficiencies of our understanding of the principles behind the design and implementation of computer based learning environments and the development of associated pedagogies. The need for research in this field was emphasised in the preceding section.
- 4.2 Because of the inadequacy of our present knowledge, the number of entry points for potentially useful research in this area is very large indeed, and certainly too large to concentrate the attention of the research community in any particular direction. It is this, together with the small size of the active research community in the UK, which has contributed to the lack of focus and diffuseness of interest within the research community referred to previously. This point was amply illustrated by the results of a "straw poll" which was conducted among researchers, academics and other interested people both in Britain and North America during 1982. In the course of unstructured informal conversations, colleagues were asked their opinions as to the research problems in this field which most merited urgent study. The variety and depth of their replies may be judged from the list of "Areas of Concern" given in the Appendix. This list was prepared from notes taken and must certainly not be seen as representing the results of any systematic survey. It does, however, demonstrate both the lack of clearly over-riding priorities and the magnitude of the task facing the research community.
- 4.3 There is an immediate need for a very large amount of research into all aspects of IT and education. It is quite obviously beyond the resources of any single body to initiate or to support all of this urgently-needed investigation. The problems are complex, demanding inputs from a wide range of academic and methodological disciplines, and there is consequently a considerable risk of fragmentation and dissipation of effort.
- 4.4 The funds available under the present initiative are meagre, and one might even be tempted to say inadequate, in relation to the magnitude and significance of the subject. It appears advisable, therefore, that these funds should be used to commission a limited number of specific research projects rather than being directed through the usual channels of open bidding and peer evaluation. Although there is much to commend the latter policy it is believed that by commissioning a relatively small number of targetted studies, the Council has a considerable opportunity to impart direction and momentum to the small and under-funded research community without distracting from the existing peer evaluation system. There are many disadvantages of commissioned research, especially vis-a-vis individual creativity and academic freedom, but such a policy would have the salient advantage in this case of maintaining the integrity and coherence of the initiative. At the same time, however, it is most important that independent proposals should continue to be encouraged and supported.

Research Programmes

- 4.5 No research programme can be all-inclusive and, whatever specific proposals may be made, there will inevitably be omissions. In a field as wide and as open as the present, this is doubly true. No proposals are made here for the evaluation of specific styles or items of courseware. This exclusion is partly due to the attention given to evaluation within MEP and SMDP initiatives, but chiefly stems from a belief that the present generation of educational software is, in general, so poorly designed that it does not provide an adequate basis for significant research (see also Hawkrige, 1983). In addition it is not believed that the Council should support ex post facto evaluation of established curriculum developments.
- 4.6 Some topics have been omitted with reluctance. For example, the subject Computer Studies has become almost by default a major part of the academic curriculum in many schools. There are many important problems, including the relative performances of the sexes, associated with this area of curriculum, and with the broader issues of 'computer literacy', but these matters were finally considered too subject-specific for inclusion within the present initiative. Nevertheless, attention is drawn to the immediate practical significance of this problem, and we hope that it might be taken up independently.
- 4.7 The opinion of Hooper (1978b) that the role of the computer in education is assured by its great versatility is concurred with and there is little point in promoting research of the "Justificatory Evaluation" type under this initiative. Adequate phenomenological criteria for such research were established under the aegis of the NDPCAL (MacDonald, 1977), and evaluation of this kind may more appropriately be handled by other agencies, such as CBT, MEP and SMDP. Similarly, support for IT applications in specific subject contexts, irrespective of the practical value of such developments, are not considered. It is considered that IT application development is currently dominated by "technology-push" rather than "market-pull" factors. In such a situation, it seems inevitable that as new technologies become available they will be tried and tested in subject contexts and evaluated according to extant criteria. It is believed that in this context, the best objective for commissioned research is the provision of appropriate conceptual tools for the design and evaluation of educational experiences at a deeper level of analysis than is currently possible.

Research Programmes

- 4.8 The fundamental strategic need in this context is for research which will contribute to the information base and the theoretical models which will inform the design and implementation of learning experiences based on the application of information technologies in a variety of contexts. At the same time the past experience of curriculum development has been noted and it is concluded that there is a parallel need for understanding of management structures and information flow within the education profession, leading to efficient management of changes in educational practice and organisation.

- 4.9 Within this strategic framework, two directions for programmes of research are identified. The first gives attention to the styles, strategies and processes of learning with IT, and this programme is entitled

Learning Processes and Information Technology

The second programme would be concerned with the effects of the technology on and in the curriculum, and with the formal and informal system through which information and knowledge are transmitted within, into and out of the educational system. This programme has been called

Curriculum and Information Technology

- 4.10 The complexity of the problems to be addressed by these programmes will demand a high degree of multidisciplinary collaboration. This implies effective recourse to the specialist skills and knowledge of high-level practitioners from a variety of relevant disciplines. Such collaboration might be expected to benefit from synergy, and eventually lead to new insights into the underlying principles. The Open University's CAL Research Group is one good example (there are of course others) of this principle in action.

4.11 Learning Processes and Information Technology

4.11.1 This programme title would include studies directed towards gaining information about the direct and indirect effects of IT based educational environments on the learner and the process of learning. Such research might give particular attention to the styles, strategies and processes of learning required or facilitated by IT in different contexts. Interest might also be directed towards the effects of contact with IT devices on cognitive development and organisation, motivational dispositions, individual behaviour and social interactions.

4.11.2 Research under this title would provide an information base for courseware designers, for teachers wishing to design and develop new learning environments, for curriculum developers and for cognitive scientists. In addition, we might point out that there are many points of convergence within this programme with the long-term strategic objectives for Advanced Information Technology (AIT) identified by the Alvey Committee, notably in the fields of Software Engineering (peripherally) and more directly in Man-Machine Interactions (MMI) and Intelligent Knowledge-Based Systems (IKBS).

4.12 Curriculum and the Information Society

4.12.1 Research under this title would be directed towards the curricular effects of IT, both directly, through the adoption of the technology for teaching and learning, and indirectly, through the influence of the societal, economic and personal effects of the technology on schools' thinking about the curriculum. Research findings within the context of this title would increase

our understanding of educational information systems (Dalin, 1978), and would support the planning of strategies for the dissemination of information and new ideas or practices. The research would be of great direct value to those concerned with teacher education, with software development and with the management and logistics of curriculum evolution.

A Research Unit for IT and Education

- 4.13 We have come to the conclusion that there is a very strong case for the establishment of a Technology Centre dedicated to multidisciplinary research into the educational significance of IT, with particular emphasis on the principles behind the design and implementation of technology-aided learning experiences.
- 4.14 The principal function of the Centre should be the conduct and co-ordination of research in this field. Subsidiary functions would include contribution to the initial and in-service education of teachers and educational administrators, and the training of research workers in a sphere of acknowledged and growing importance. In addition, the Centre should be free to provide research and consultancy services on a commercial basis for a variety of public and private agencies. The unit should be so constituted as to permit and encourage progress towards eventual financial independence.
- 4.15 It is important that the unit should have access to academic and research expertise in an appropriately wide range of disciplines. In practical terms this implies establishment within a University or similar environment. The establishment of such an organisation would in our view encourage the growth of collaborative approaches to complex societal and educational problems, whilst conserving the insights so gained.
- 4.16 In addition to its obvious role as a centre of excellence, the unit should become a focus for the provision of supportive research within the context of the world-wide market for traded services in education referred to earlier. This commercial orientation would bring the unit directly into the ambit of the AIT Directorate advocated by the Alvey Committee, and the funding possibilities inherent in this convergence of interest should be explored further.
- 4.17 Possible functions and relationships for the proposed Centre are summarised diagrammatically in figures 1 and 2.

The Technology Centre is conceived as providing a focus for Development and Research and as such it is seen as :

- . providing the co-ordination for a cohesive, stimulated research programme
- . undertaking a limited amount of multi-disciplinary research, primarily with a view to "promotion" or "interpretation"
- . providing a focus for research collaboration and stimulation (synergy) between research workers and also with their 'customers'

- . providing a research and development base for the industry in traded educational services
- . disseminating research results, information and data on practical experience stemming from the research.

As such the Technology Centre is expected to be a small, efficient unit having as its core a small, multi-disciplinary team but supported with the appropriate administrative aids which are essential to the proposed role. The Centre should be located in an environment which is capable of providing the fullest support, the bulk research activities are expected to be carried out elsewhere. Ideally the Centre should be supported by a sound infrastructure of Information and Educational Technology, teacher training and experience and commitment by the Local Education Authority.

5. POTENTIAL RESEARCH PROBLEMS

5.1 This section considers a number of significant and potentially tractable research problem areas which are believed to merit inclusion under the programme titles presented above.

5.2 Methodological Issues

5.2.1 Much research in the social sciences deals with complex problems where the methodological paradigms associated with the 'hard' physical sciences are either difficult or impossible to apply with adequate rigour. Educational research in particular typically addresses problems where the precise quantification of variables is often technically or even logically impossible, and where the components of interacting systems may not in any case be identifiable with any certainty. This combination of complexity with indeterminacy may on occasions invalidate the rigorous statistical assumptions on which many classical research designs are based. Much past (and present) research has been marred or rendered meaningless by failure to take account of these difficulties. It is a commonplace observation, therefore, but one which needs restating, that great emphasis must be laid on the appropriateness of research designs in this field. There will inevitably be many important problems where 'classical' methods, such as controlled experiments, are entirely appropriate, but there will equally be others which do not lend themselves to such approaches. The procrustean logic which demands that all research designs must fit into the same methodological 'bed' is rejected.

5.2.2 The dilemma of the 'measurable' versus the 'significant' is an old problem of educational research, but it remains a live issue for all that. It is vitally important in a new field to tackle issues which are believed to be fundamental, even where available research methods are apparently inadequate.

5.2.3 Fortunately one of the great strengths of the Social Science approach to research is the variety of rigorous methodologies which can be deployed. This variety may be augmented by the assimilation of new paradigms. Thus, research methods such as case study (Walker, 1974; Stenhouse, 1982), the General Systems approach (Hughes, 1979) and Organisation Theory (Dalín, 1978) are now gaining acceptance. It is to be expected that the synergetic multi-disciplinary research which has been advocated will give rise to research designs which are unorthodox in the context of educational or social science research. Such unorthodoxy should be tolerated, so long as due rigour can be maintained.

The Need for Effective Communication

5.3 It is obviously essential that any research which is supported under this initiative should inform and influence the appropriate sections of the academic and research communities. It is,

however, no less important that teachers, teacher educators, administrators, politicians and the general public should be informed and influenced. Whilst it is certainly inevitable that some problems will necessitate highly technical research (and there is no question but that such research should be supported), **the need to communicate must remain uppermost in researchers' minds.** Research which demands rare and esoteric skills for its comprehension, or which requires several successive layers of interpretation and reinterpretation, or which is so tightly constrained as to defy application, is unlikely to inform or influence anyone but the narrowest specialists (and often not even them). At a time of financial austerity, amid increasing demands for 'relevance' and 'accountability', failure of communication may be little short of disastrous to the progress of research and the interests of the educational community which it serves.

- 5.4 The argument is not for the reduction of research reports to a form of minimal Basic English, or for the abandonment of all research which might conceivably be unintelligible to the man in the street. Rather the argument is that it ought to be possible for highly literate scientists to design and implement high quality research and, at the same time, communicate the results of their work effectively to the widest possible audience (and not just peer groups) and that recognition should be accorded to the importance of this. **Due attention to communication strategies should be given at an early stage of any research projects supported under this proposed initiative, and the potential role of the Technology Centre could be important here.**

Research Problem Areas

- 5.5 The remit for this report was to identify significant and tractable research problems in the field indicated by the Working Group. In this section the general features of the problem areas identified are outlined, and in a later section (6) a number of specific project outlines are developed.

Learning Processes and Information Technology

5.6 Effects of IT on Children's Thinking

- 5.6.1 We have little idea how children's minds may be influenced by the experience of growing up in a computer-based society. Young children today are growing in an environment where computers are all around, and even form part of the stock-in-trade of television cartoon characters. It would be valuable to know what effects this 'sub-cultural' exposure to the information society is having. Computers and related devices might be expected to provide some, many or even most children (we have no real idea) with metaphors, models and perceptual frames which might have significant effects on the interpretation of experience and the organisation of knowledge. The role of computers in what Bernstein (1975) called the 'Invisible Pedagogy' of the pre-school years can only be a matter for conjecture. We have no baselines against which future developments may be interpreted, and if no research is carried out in this field very soon, the opportunity for studying comparatively "computer-naive" children may be lost completely. If such is the case,

then future educators may come to regret our laxity, just as we now regret our lack of understanding of many of the effects of television.

5.6.2 We are equally ignorant of the effects and influences of the deliberate application of IT devices in educational environments. Most of the research on the "cognitive effects" of computers has (in our view) been trivial and badly designed. There has been a tendency to concentrate on the "effectiveness" of software packages in raising children's scores on various standardised attainment tests, chiefly in mathematics and English. Difficulties over the appropriateness of criterion tests have often not been clearly appreciated, and the problems of design and interpretation associated with situations when hardware, software and pedagogy are all simultaneously innovatory have generally been ignored. Much research which has claimed to investigate cognitive effects of computer assisted education has been little better than useless. More to the point, however, such studies may obscure the search for deeper understanding of learning processes and strategies by substituting simplistic goals, while attention to test scores as evaluative criteria may serve to mask the significance of underlying cognitive effects of the technology. **We need research models which give more direct access to children's thinking than indirect inference based on test scores.**

5.6.3 Papert (1980) argued, though without evidence, that early experience with computers might provide children with reasoning strategies (iteration, debugging, concrete models etc) which could profoundly influence the pace and pattern of cognitive development. In Papert's view, many of these effects might not be manifested except after a period of years. This assertion seems worth taking seriously (though Papert himself did not attempt to investigate it), and **there is a good case for long-term research, beyond the life span of the average research grant.** This is one aspect of research which might be supported through the Technology Centre.

5.6.4 Another source of research interest in this general area might relate to the effects on children's thinking of the linguistic and procedural structures embedded in computing environments, and of which teachers may not even be aware. The linear algorithmic style of procedure which is characteristic of most current educational software (and which is implicit even in the use of LOGO) may well be valuable in providing some children with a procedural framework for problem decomposition and solution, but it may be for some children a source of dissonance where the child's own preferred thinking style is not compatible with such a model. The ideas of Pask (1975) on cognitive styles and Mitchell (1982) on knowledge structures may be directly relevant here.

5.6.5 This is both an important and an extensive field, where research might be expected to make substantial contributions to educational theory and practice. Studies in this problem area would be expected to draw on

knowledge and insights from cognitive psychology, from computing, from educational research, from classroom teaching and, significantly, from the vigorous tradition of artificial intelligence (AI) research which is already proving so valuable to our understanding of perception and cognition. Synergesis between these disciplines could lead to the construction of models of the complex processes which occur when children interact with computers and related devices. In any case, the development of a model of the learning process would be of the greatest consequence even to conventional education, and so this general field may be held to embody problems which are of fundamental importance to education.

- 5.6.6 Models of learning processes and the organisation of knowledge in various contexts would be necessary to the understanding of the effects of IT on children's thinking. At the same time, such models would be of great value in the design and implementation of learning environments based on the new technology. Research in this field might be linked with the development of IKBS. The production of an expert system in the field of primary mathematics was suggested by the Alvey Committee as a possible "Demonstrator Project" within their proposed IKBS programme, and there is clearly some possibility for collaboration and cross-fertilisation here.

5.7 Investigative Learning with Information Technology

- 5.7.1 Investigative learning is acknowledged to be a potentially significant educational activity in the context of the 'curriculum for the information society'. Such learning involves many skills in the organisation and manipulation of information, but little is yet known about the design and management of investigative learning environments, or of the cognitive processes involved in such learning. This has been difficult to study because of the inaccessibility of the processes, which could only be inferred indirectly from their products until the advent of computers permitted more direct (but still inferential) observation.
- 5.7.2 IT as such is not essential for investigative learning, but computers and related devices provide many opportunities for the design of appropriate environments. Thus, computer-based simulations and models may be used as the bases for deductive or inductive explorations, whilst databases have many potential applications in a whole range of subject contexts. Added to this undoubted educational value, there is the fact that IT devices offer unique facilities for the capture and analysis of data regarding learners' behaviour and intellectual strategies.
- 5.7.3 Of course, there are many questions at both practical and theoretical levels which must be answered if the full potential of investigative learning is to be realised. We need to know, for example, what (if any) structure should be built into databases, and whether knowledge about information structures is helpful to learners (bearing in

mind the suggestion of Minsky, 1975, that intelligence might be definable in terms of one's knowledge of one's own data structures). We need to know also what limits need to be set on learners' freedom to explore, and whether such constraints affect the nature of learning processes. It would be valuable to know how learners' attitudes are affected by reward contingency (Harackiewicz, 1979), by teachers' expectations or by other external factors.

5.7.4 At a more fundamental level, we need to acquire suitable models of rule acquisition and heuristic processes, and of goal direction and meta-planning in self-organising cybernetic systems.

5.7.5 Studies of investigative learning should have existing expertise in non-technology-based information techniques on which to build (Schools Council, 1981; Rowbottom, 1983). Research would require expertise from psychology, education, computing and AI studies. Once again, the relationships between the theoretical models required in this field and the research and development strategies laid down by the Alvey Committee must be emphasised. The potential for collaboration must be fully exploited.

5.8 Cognitive Impoverishment and Information Technology

5.8.1 Visually and aurally handicapped people may incur varying degrees of 'cognitive impoverishment' due to their perceptual deficiencies. Similar impoverishment may, however, result from restrictions on experience imposed by social or ethnic customs and practises or from experiential constraints imposed by many kinds of physical or mental handicaps. Cognitive impoverishments of one kind or another may cause many people to be accidentally and unjustly excluded from effective participation in IT-based educational, occupational and leisure activities because of imperfect communication with the devices. This does not necessarily refer to the problems of physical communication (which may be real enough), but rather to difficulties with intellectual interaction with IT systems.

5.8.2 A basic underlying problem here is in the nature of learning processes and knowledge organisation where cognitive frames and models may be defective. This demands understanding of the roles of cognitive frames and mental models in interaction with technology, and of the styles, strategies and techniques of interaction which can best compensate for various deficiencies.

5.8.3 This is an aspect of Man-Machine Interaction (MMI) where the social science research perspective could be extremely valuable. Knowledge gained here will, of course, contribute to the well-being of handicapped or underprivileged people as suggested above, but it might also be significant in our understanding of learning and organisation of knowledge in the presence of incomplete or degenerate data.

5.9 Motivating Effects of Information Technology

- 5.9.1 It is often accepted as axiomatic that computers and related devices are intrinsically motivating for learners. Such a sweeping generalisation may be rather difficult to sustain, but hard evidence of any kind is notable for its scarcity, and there is a clear need for research.
- 5.9.2 The field is both complex and difficult, but the question of motivation is crucial to the business of education (Raven, 1975, op cit), so that even limited insights may have great practical value. Motivation may be an intensely idiosyncratic phenomenon, depending on a plethora of personal and contextual factors such as intelligence, personality, environmental conditions and many other influences which can scarcely be identified, much less experimentally controlled. Research in this area is not likely to yield globally applicable generalisations: there are neither universal ills nor sovereign remedies in education, and it is futile to search for them. Nevertheless, what little understanding might be gleaned here could influence the design and organisation of learning environments and educational materials based on IT. This knowledge might also, as Malone (1980) has indicated, be valuable in the design of computer-based leisure materials.
- 5.9.3 Research in this problem area might bring together techniques and expertise from psychology, psychophysiology, computing, engineering, sociology and education. Appropriate research techniques might include observation, interview, physiological measurement and exploitation of the data capture potential of IT devices. The latter would be a significant methodological advance in itself, and one might point to the Open University CALRG use of the CYCLOPS device (Everts, 1982).
- 5.9.4 The results of research on motivation and IT would support the design of courseware as well as the design and management of learning environments in different contexts. Such information would also be valuable in the development of intelligent tutorial systems. Furthermore, as Eisenstadt (1981) has suggested, IKBS research in the next few years will be increasingly concerned with the modelling of affect and emotion (a fact which has been recognised already by the Council in its support for computational modelling work in this field at Warwick University). The stress laid by the Alvey Committee on MMI might also be recalled here.

5.10 Information Technology and Social Interactions in Schools

- 5.10.1 The capacity of new technologies to stimulate and support new styles and strategies of teaching, learning and even thinking could bring about changes in social structures and interactions within schools. These changes, which might include altered patterns of esteem and deference as well as new friendship structures and routes for

peer-group influence, could have quite considerable effects in the social and intellectual effectiveness on schools curricula.

- 5.10.2 Moves towards independent, collaborative or peer-mediated learning might be expected to affect the management practices of teachers. These changes may themselves affect both the role and authority of the teacher and even pupils' general attitudes towards authority and authority-figures. Affective adjustments of this kind could have significant consequences in terms of social structure and stability.
- 5.10.3 Research in this field would require expertise from psychology, sociology and educational research. Appropriate techniques might include direct observation, interviews, questionnaire-based surveys and sociometric analysis. The research would have existing foundations of classroom observation studies on which to build, and even more specially designed techniques for observation notation (Beeby, Burkhardt and Fraser, 1979). **In view of the fact that staff as well as pupils are likely to be influenced by the new technology, the tradition of research in industrial and commercial contexts might also be relevant here.**
- 5.10.4 Information arising from research in this field would be interesting and valuable to curriculum developers, to educational theorists, to teacher educators and to courseware designers, as well as to classroom teachers wishing to organise new and effective learning experiences for their pupils.

"Watching Briefs"

- 5.11 There are a number of developments related logically to the programme title "Learning Processes and Information Technology" where it might be held more appropriate for the Council to hold a "watching brief", rather than to initiate activity at the moment. Some of these developments are still in very early stages, some of them relate to other initiatives already discussed, and some might give rise to research problems appropriate to the Council's attention in the not too distant future.
 - 5.11.1 Videodisk Technology and the Curriculum: interactive videodisk (IVD) is now technically feasible, and a number of systems have already been demonstrated. At the moment the techniques of IVD production are too complex and costly for educational research application within the context of this initiative, but we believe that research will soon be needed in order to provide a knowledge base for the design and educational application of IVD materials. CET has already recognised the potential of this technology and has a strong interest in its development.
 - 5.11.2 Educational Databases: query languages and other techniques for the structure and interrogation of educational databases are becoming widely available, and the use of IT media such as PRESTEL is growing rapidly

(Thompson, 1982). There is a need for research in this field (in which CET is also involved), perhaps linked with the proposed work on investigative learning.

- 5.11.3 The Home Learning Environment: developments such as teletex and cable networks will support new styles of home-based formal and informal education. For example, the new IT media could provide solutions for problems with minority subjects in school curricula through sharing of teaching expertise. Alternatively IT could sustain the viability of small schools in remote communities, whilst leisure learning through IT media could supplement voluntary adult education systems. Commercial hardware and software houses are likely to be swift to recognise the marketing opportunities inherent in IT-based learning environments, and will undoubtedly strive to develop educational and quasi-educational materials for this market. There is some danger that such commercial material might not be fully compatible with UK educational thought and practice, and may even have detrimental effects on education. With an appropriate design base, however, IT-based distance learning could become a most valuable adjunct to formal curricula. Research is needed here to supplement and extend the valuable work already undertaken by the Open University. This research might involve active collaboration with CET, MEP, SMDP, OU, BBC, IBA, British Telecom and commercial publishing interests.

Within the Home Learning Environment it would also be appropriate to include the needs of Continuing Education. These encompass both vocational and non-vocational needs as well as the issue of distance and time in course attendance. Issues which may well be properly addressed by IT. It should also be noted that some of the issues of Continuing Education are similar to those contained in the area discussed in 5.11.4. (See also Rushby, 1981)

- 5.11.4 Computer Based Training: there is a growing involvement in Industry and the armed forces with Computer Based Training. This may be felt not to have educational significance by some but it does

- . represent one end of the spectrum where high motivation and clear learning objectives exist
- . have a high industrial value either for skills maintenance and learning within organisations or for imparting knowledge overseas for exporting organisations

In particular many of the issues that need to be addressed also form aspects of the general educational scene. It is an area where there is already a perceived need for research (at least a recognition of ignorance of design criteria) and where the problems will have to be solved within the industrial/commercial environment if the research community does not provide appropriate and useable results.

- 5.12 These "watching briefs" would demand close contact with research and development in a variety of fields, and would necessitate the ability to step in with research funds and expertise at quite short notice. We believe that this short-term enabling function might become one of the responsibilities of the proposed Technology Centre.

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5.13 The Adoption of IT by Schools

- 5.13.1 The factors which inhibit or promote the adoption of computers and related devices by teachers are not known or understood. Quantitative inferential data-gathering techniques seem unlikely to illuminate the plethora of personal, social and professional interactions which are probably involved. It is considered that there are grounds for case studies of a relatively small number of schools. Such studies might be expected to contribute to our understanding of curriculum diffusion processes, and should also provide practising teachers with aids to the analysis of their own problems.
- 5.13.2 Analytic methods based on General Systems Theory have already been applied successfully to the analysis of factors associated with development of Computer Studies in the secondary curriculum (Hennessey, 1982). This framework could provide a means of understanding the interactions which affect the adoption of IT by schools, as could Dalin's Organisation Theory (Dalin, 1978, op cit). A case can also be made for direct advisory participation in decision making processes (see, for example, Richardson, 1975). Bearing in mind the earlier strictures about the need for effective communication, it is envisaged that researchers would be free to make their observations and conclusions available to the subject schools, so long as any such inputs were treated as equivalent to any other source of in-service support.
- 5.13.3 The results of this research would be particularly valuable to teacher educators, to educational administrators and, of course, to school staff concerned with the development of curriculum. It is of particular interest because it does not relate to a specific curriculum project, but to generally applicable innovations of thinking and technology. Stenhouse (1975) noted the importance of knowing how difficult new curricula are to implement in less than ideal circumstances. Research such as is being advocated here would help to meet this information need, and would contribute significantly to a tradition of curriculum research which focusses onto problems and responses to them, rather than on the invention of ambitious solutions before the problems have been properly studied.

5.14 The Management of Curriculum Change

- 5.14.1 The pace of curriculum change already in progress, and the acceleration of the pace of change which is to be anticipated in the years ahead will inevitably demand

inspired and effective management if the educational system is not to suffer chaos and confusion. This fact has been readily appreciated in commerce and industry, where management problems associated with the adoption of new technologies have received much attention in recent years (for example, Forrester, 1980; Marcson, 1970; Twiss, 1981). There has, however, been little attempt in Britain to apply insights and techniques from outside of education to the management problems associated with curriculum change. There is a need for research designed to evaluate resource and personnel management strategies at national, local and school levels.

- 5.14.2 This research would need expertise in economics, statistics, public administration, systems analysis and education. The findings would be of immediate value in the context of the developing 'curriculum for the information society', and an action research strategy might be appropriate here. Results would influence national and local government support programmes, and would also be applicable to the training of headteachers and other senior teaching and administrative staff in education.

5.15 Special Interest Groups and the Curriculum

- 5.15.1 The diffusion of ideas and information about IT and its educational application is, despite recent large-scale central government intervention and the valuable and long-standing contribution made by bodies such as AUCBE and CEDAR, largely a process of 'periphery-periphery' activity. Personal contacts and quasi-formal structures such as 'user groups' have played significant and possibly central roles in the dissemination of new ideas (though not necessarily on their widespread adoption within schools). Further dissemination strategies would be greatly aided if the role of special interest groups were understood and suitably exploited.
- 5.15.2 Research here would use school-based case studies to investigate ways in which non-formal information networks influence the school curriculum, with particular attention to computers and other aspects of IT. Findings would be significant to the promotion of strategies for the management of curriculum change.

5.16 Automation and the Curriculum

- 5.16.1 It is widely appreciated within education that curricula will have to evolve in line with the personal, social and economic pressures created by domestic, commercial and industrial automation. Little is known about the ways in which current debates on the relationships between industry and education are affecting curriculum outside of the obvious context of quasi-vocational subjects. The situation will be complicated by a recently announced DOI initiative to help schools obtain industrial robot simulators, and that there is a need for research.

- 5.16.2 Research would investigate ways in which projections about the educational requirements of automated working and leisure environments can influence curriculum planning and implementation at school level, and the extent to which this is influencing pupils' awareness of the major issues involved (particular attention might be given to sex differences). At a more generalised level, the research would elucidate ways in which social changes and public concern are transmitted into curriculum changes. Results of the study could be applicable in curriculum planning, in initial and in-service teacher education, and would inform those government agencies concerned with influencing the direction of curriculum change.

5.17 Courseware and the Curriculum

- 5.17.1 Relatively few teachers have either the skills, the time, or the inclination to design and write their own courseware, so that in the great majority of classrooms, the IT-based learning materials used will come from outside sources. Software of all kinds necessarily embodies linguistic structures and procedural models which may not be immediately manifest to the user (or, cynics might suggest, understood by the writer). Some of these hidden structures may be superficially or fundamentally incompatible with the curriculum and ethos of schools in which the courseware is applied. Thus, much currently available courseware is based on Skinnerian behaviourist models of learning processes. Whereas such models may be consonant with the curriculum philosophy of some schools or the knowledge structures of some subjects, it may be entirely inappropriate in many cases.
- 5.17.2 Research is needed into the influence of software styles and structures in implicit and explicit curriculum models applied by schools. The studies would use school-based observation techniques as well as formal analysis of courseware. Suitable evaluative criteria would be needed, and expertise would be required from cognitive psychology, curriculum evaluation research, computing and linguistics. Information from the research would be applicable in the training of teachers and in the design and evaluation of software.

5.18 Resource-Rich Environments

- 5.18.1 Computers and related devices are still rare resources in limited supply in most schools, a fact which may be hindering the pace of curriculum development. There are reasons to believe that in future, schools will be far more richly resourced with IT devices than they are at present (though this involves some assumptions which are as much political as technological). Once the application of IT is no longer limited by resource availability, more attention will be given to the basis for its use: whether, for example, it is to be applied in classroom-based, resource-based or library-based environments. Teaching strategies and the design of educational experiences will depend on teachers' and

pupils' perception of the technology (and there may be significant subject related components to these perceptions).

5.18.2 Some schools are fortunate in having relatively high levels of hardware and software resourcing even at present. There is a strong case for research in these resource-rich environments. The research might aim to develop a typology of usage styles and to determine the chief operational features of these different styles. The objective of such studies would not be the identification of a single "best" style of usage for IT in schools, but the development of an information base for future curriculum planning. This information would be useful to courseware designers as well as to teachers and administrators. In addition to the more immediate and practical applications, observations of different modes of IT usage could alert teachers and researchers to problems and inconsistencies which require explanation or further detailed investigation.

5.19 As we noted earlier, this programme leaves untouched many important areas for research. The eclectic approach has been made necessary by the vast amount of research which is plainly needed. Recommendations have been avoided which apply to specific subject areas within the curriculum, although it is fully recognised that many significant problems may have subject-related components. However, that the areas which have been discussed above are worthy of study and are fit subjects for attention both by virtue of the appropriateness of the social science research perspective and in view of the importance of the research area.

6. PROPOSALS FOR COMMISSIONED RESEARCH

6.1 Research Priorities

All of the problem areas discussed in the previous section are important, and that research should eventually be initiated and supported in all of these areas. However, it is clear that not all of the problems referred to are of equal importance or priority, and an attempt has been made to identify certain problems within each of the proposed programme titles which have some claim to high priority.

Learning Processes and Information Technology

6.2 Research within this programme is intended to investigate what it is that the use of IT does to and for learners. Such studies should furnish an information base for imaginative and productive thinking about the design of learning experiences. It is important that such research should be focussed on the future rather than the present, anticipating the availability of more 'intelligent' devices than are currently available. The Council should initiate research which will relate to a demand for courseware which reacts intelligently to the needs of the learners. This presupposes a high level of understanding on the part of courseware designers of the nature of learning processes.

6.3 Consideration of this field repeatedly draws attention to one particular theme of apparently fundamental importance, namely the need for models of learning processes in different contexts (see Hawkridge, 1983; Howe, O'Shea and Plane, 1980; Minsky, 1975). As Cooper (1980) noted

"Perhaps the real challenge now is to combine the collective expertise of the computer scientist, the cognitive psychologist and the subject expert to develop true models of knowledge bases and acquisitive skills for different topics. Our systems need to become 'intelligent', flexible, and capable of learning themselves in order to be truly valuable to the student".

6.4 It is believed that the first priority in this field should be for research directed towards models of learning process and the organisation of knowledge, applicable to both the design of educational environments and the understanding of the needs of learners in various contexts. It must be stated that this priority is not a direct consequence of any 'technological imperative', but relates to a fundamental need of education, namely the need for models of learning processes which can become the formal bases for educational experiences. Irrespective of the medium of education, teachers need to understand how learning takes place and how it may be promoted or inhibited, and this understanding has been a desired goal for many centuries. Modern technology supplies routes towards the achievement of the goal: it does not supply the goal.

6.5 Computational Models of Learning: A Proposed Research Initiative

- 6.5.1 Minsky (1975, op cit) argued that the most promising route to the development of useful models of learning processes lies in studies based on the AI research tradition. As the Alvey Committee noted, however, this field of research is not only difficult, it is essentially long term. Whilst supporting the case for research of this kind, it must therefore be observed that it is almost impossible at this time to lay down a precise programme for research, or to formulate detailed and fully operationalised research questions. This difficulty was well stated (in another context) by Cronbach and Snow (1969):

"If it is true that investigators have only rough ideas as to the variables that are most likely to enter into profitable interactions, then research must probe flexibly. We can understand the desire of any agency that supplies funds for research...to have an explicit plan outlining precisely what will be investigated, but any plan for finding a path through a swamp must be vague... To sit on the edge of the swamp and plot out a course saying where the research will be some number of months later is an exercise in naive fantasy".

- 6.5.2 Bearing this in mind, it is proposed that research be initiated within a framework directed towards computational modelling of learning processes. The long-term aim of the initiative would be the development of criteria for the design of curricular materials and courseware which both exploit the full potential of any available technology and relate as fully as possible to the learning styles and strategies of individuals.
- 6.5.3 It is expected that this initiative should supply an educational "market-pull" component to complement the "technology-push" orientation of the IKBS developments proposed by the Alvey Committee. Careful co-ordination of educational and technological perspectives should ensure that the models of the learning process and the organisation of knowledge which become incorporated into the coming generation of intelligent devices and expert systems will not be excessively machine-oriented. We believe that by reflecting the complexities of human processes, styles and strategies as faithfully as current technology and theoretical understanding might permit, such devices will both maximise user confidence in their conclusions and avoid the undesirable consequences of the imposition of inappropriate process models on the structure of educational materials and environments. It is concluded that these requirements will best be met through the vigorous assertion of a strong social science perspective on research in this field.
- 6.5.4 The effective research community whose attention might be brought to bear on this initiative is both small and fragmented. Few groups embody or have access to the full range of expertise which is likely to be necessary, and so

existing groups will need to be strengthened. It is suggested that the training of researchers be promoted through the support of studentships and fellowships linked to this initiative.

- 6.5.5 The initiative will need to run for at least five years, and ten would be a more realistic period, though much could be achieved in the shorter term. Substantial expenditure will be necessary, especially in the early stages. There can be little doubt, therefore, that this will prove an expensive venture, but this merely reflects and underlines the magnitude and significance of the problems involved. It should not be implied that this initiative can do more than to provide a rough framework for educationally applicable models and a series of signposts for future research. It is most unlikely that we shall see the sudden emergence of any pedagogic equivalent of the Unified Field Theory!

- 6.5.6 Four contributory sub-programmes are envisaged within the structure of the project, with each sub-programme corresponding to one of the research problem areas outlined previously. Each of these sub-programmes would contribute a different perspective on the overall problem:

Young children's thinking: involving modelling cognitive development and the structuring and activation of cognitive frames.

Investigative learning: involving modelling of heuristic processes, rule acquisition and meta-planning.

Cognitive impoverishment: involving study of the structuring and activation of cognitive frames in the presence of inadequate or degenerate data.

Motivation: involving modelling of goal-direction affect and emotion in self-directing systems.

- 6.5.7 It would be advantageous for some of the above sub-programmes to be contracted to different research groups in order to maintain diversity of outlook. Funding arrangements should be sufficiently flexible to permit such a policy. The scheduling of the programmes within the overall structure of the project will depend to a large extent on the progress of the research and on tactical priorities established by the Project Director in consultation with the Council. Such details of management policy are obviously impossible to predict at the moment.

- 6.5.8 It is our opinion that it is quite unrealistic to consider allocating less than £500,000 to this initiative, and that even this amount would not be adequate. It must be recalled that the NDPCAL involved expenditure in excess of £2.5 million, including £200,000 for an independent evaluation (Hooper, 1977). The Secondary Science Curriculum Review has at its disposal a sum of £850,000

(West, 1982) for an exercise which could be rendered invalid by future developments in technology and in educational theory. Attention has been repeatedly drawn to the parallels which exist between the priorities which have been identified and the Alvey Committee's proposals for research on the "Enabling Technologies". The Alvey Report spoke of an investment of about £57,000,000 in academic research and training over five years. It is considered that there is a clear case for the establishment of links between the Council and the AIT Directorate proposed by Alvey. The role which the Technology Centre might play in this context has already been alluded to.

6.6 Other Projects under this programme title

- 6.6.1 Growing up in a "Computer Culture": there is an urgent need for research into the 'invisible pedagogy' to which young children are subjected when they grow up in a computer-rich society. This research, whilst not of the same fundamental importance as that outlined above, needs to be done early in the lifetime of the programme simply because of the pace at which society is now changing. We need 'baseline' standards against which future developments may be addressed, and the opportunity for establishing these baselines is rapidly receding. Neglect of this opportunity might be greatly regretted in the future. Quite apart from the more or less 'archival' aspect of this research, studies in this field would serve as valuable sources of protocols on which ideas about more fundamental aspects of cognitive research might be based.
- 6.6.2 It is anticipated that this research would take two years. (This would depend on the sampling and data-gathering strategies selected). The work might build on foundations laid by the SSRC funded research into early cognitive development carried out at the Thomas Coram Research Institute; and form the basis for long-term investigation of the cognitive effects of growing up in high-technology societies. There are many subsidiary problems in this area, where research could contribute to our understanding of children's thinking, and the hope is that these problems will be taken up by researchers.
- 6.6.3 Social Interactions and IT: there are a number of research groups in Britain who have expertise appropriate to this field. Research here would have a somewhat lower priority than the projects outlined above. This does not imply that the work is not considered important, but simply that it does not need to be initiated quite as soon as the other projects.
- 6.6.4 There is considerable interest in classroom interaction studies within the academic community, and it is considered unnecessary for the Council to underwrite the research to quite the same extent as for the projects

already discussed. It would be best for funds to be deployed in encouraging the development and validation of appropriate methodology.

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6.7 Research under this programme title is directed towards the information systems through which changes in society or new ideas in education influence events in the classroom. Curriculum developers need to be able to exploit 'natural' information paths, and therefore the understanding of formal and informal information systems is a major priority for research. We have, it must be said, a fair body of information about how not to disseminate ideas (for example, Shipman, 1974). **We now need to advance to a model of organisational change which will permit us to operate more effectively in the future.**

6.8 Uptake of New Technology by Schools

6.8.1 The conclusion is that the greatest priority within this programme title is for research into the uptake of new IT by schools. As noted earlier, a suitable approach would be through linked case studies. The research would use detailed case studies and condensed case study methods in order to maximise sample size. For the information to be directly useful before it becomes obsolete, it must be made available to schools quite rapidly. It is envisaged that this project would publish a series of interim case studies for wide circulation as well as a final report directed towards more formal discussion.

6.8.2 There is currently a reasonable body of expertise in educational case study in this country, for example within the CARE group at UEA. However, research groups might well need to be strengthened with suitable expertise in systems analysis. The estimate is that the project should run for 2-3 years.

6.9 Other Projects under this programme title

6.9.1 These projects, whilst considered important, may be assigned somewhat lower priority:

- a. Management Strategies: a project running for 2 years.
- b. Resource-Rich Environments: a series of case studies, involving 1.5 years in the field. An extension to this project might involve the establishment of an experimental resource-rich environment, and would demand appropriate capital expenditure.
- c. Special Interest Groups: a one year project.
- d. Effects of Automation: a two year study, requiring case study and participant observation.

- e. Courseware and the Curriculum: this project is considered to be important, but it will depend to some extent on evaluative criteria from work under the Learning Styles initiative. The study might require 3 years.

6.10 Other Research Initiatives

- 6.10.1 The range of potentially significant research problems in this field is vast, and the research effort to date has hardly begun to define the problem space, much less provide definitive answers. It is clear that the initiatives which have been suggested must be selective, and whilst there is confidence in the conclusions, nevertheless there is still an awareness that other analyses might lead to different opinions and different strategies.
- 6.10.2 Within the programme titles and problem areas which have been defined, it is hoped that researchers and students with fertile imaginations will be able to discern foci for their own interests and expertise.
- 6.10.3 It has been argued throughout that independent initiatives should be encouraged, nonetheless it has been explained why a policy is proposed of commissioned rather than competitive bidding. There is an over-riding need for a coherent research effort and it is the hope that the initiatives proposed will act as nuclei for the crystallisation of a wide range of independent projects. The issues touched upon are vitally important, but it is crucial for the debate to be broadened. There could be a rapid growth of creative research which will be to the ultimate good of the educational system and indirectly to Britain's economy if these issues are exposed to public discussion and analysis.

6.11 Conclusion

It seems almost mandatory for researchers to conclude everything they write with a remark about the "need for further research". If we do so it is not merely acquiescence in convention but a sober statement of bald fact. We stand on the brink of one of the great revolutions in the structure and process of education - a revolution which has enormous implications, both directly and indirectly, for the future wealth of our nation. The quality of the research effort over the next few years could be instrumental in determining whether we leap blindly over the brink, carefully choose our path or simply turn our backs and accept the consequences of failure.

7. RECOMMENDATIONS

- 7.1 The Council should, as a matter of urgency, support a programme of research into the impact of IT on education in schools.
- 7.2 The funds already provisionally earmarked for this programme should not be made available through the usual channels of competitive bidding and peer evaluation, but should be used to commission a limited number of specific research projects.
- 7.3 Notwithstanding this emphasis on commissioned research, unrelated independent initiatives should continue to receive vigorous support and encouragement.
- 7.4 A multidisciplinary synergetic approach to research should be encouraged wherever possible.
- 7.5 Tolerance should be shown towards apparently unorthodox research designs, so long as it can be demonstrated that due methodological rigour can be maintained.
- 7.6 The need to communicate effectively with the broadest possible audience should be given strong emphasis, and communication strategies should be considered at an early stage of any research project.
- 7.7 Encouragement and support should be given to long-term research.
- 7.8 A specialised Technology Centre should be established to act as a centre of excellence in the field of Education and Information Technology and able to attract support from other Bodies and Research Councils.
- 7.9 Research should be commissioned under each of the following programme titles:

Learning Processes and Information Technology: research concerned with the direct and indirect effects of learning with the aid of IT on learners, the learning process and the organisation of learning environments.

Curriculum and the Information Society: research into the curricular impact of IT and the elucidation of information systems through which new thinking is brought to bear on the practical curriculum.

- 7.10 The following specific initiatives should be commissioned under the aegis of the above programme titles:

Learning Processes and Information Technology:

1. For Immediate Implementation

- A major initiative directed towards computational modelling of learning and cognitive processes, with the long-term objective of providing bases for the design of learning experiences based on the next generation of IT devices.

- A study to provide baseline data for future research into the effects of IT on young children's thinking.

2. For Eventual Implementation

- Classroom observation studies of the effects of IT on social interactions in schools.

Curriculum and the Information Society

1. For Immediate Implementation

- A series of linked case studies to investigate the factors which promote or inhibit the uptake of new technology and its applications by schools.

2. For Eventual Implementation

- A study of management strategies in the introduction of IT in education.
- A cluster of case studies of highly resourced schools to observe styles of IT usage and to evaluate their effectiveness.
- A study of the role of special interest groups in curriculum innovation.
- The impact of industrial and commercial automation on the content and organisation of school curricula.
- The effects of courseware styles on school curricula. (This study would depend on analytic models from the major initiative on computational modelling, and so could not be implemented immediately).

- 7.11 Due attention should be given to the research training and education needs associated with these initiatives, and that funds be made available for studentships and postdoctoral fellowships in appropriate areas.
- 7.12 The Council should actively consult with interested bodies such as MEP, SMDP, CET, SERC, DES, and DoI, to promote collaborative funding of research, to advance the role of these research initiatives in future curriculum developments and to assert the potential role of the proposed Technology Centre in co-ordinating research and development policy.
- 7.13 The Council should take note of developments under the aegis of the Advanced Information Technology Directorate proposed by Alvey in order to advance the case for the Social Science aspect to research initiated under the Alvey Committee's proposals.

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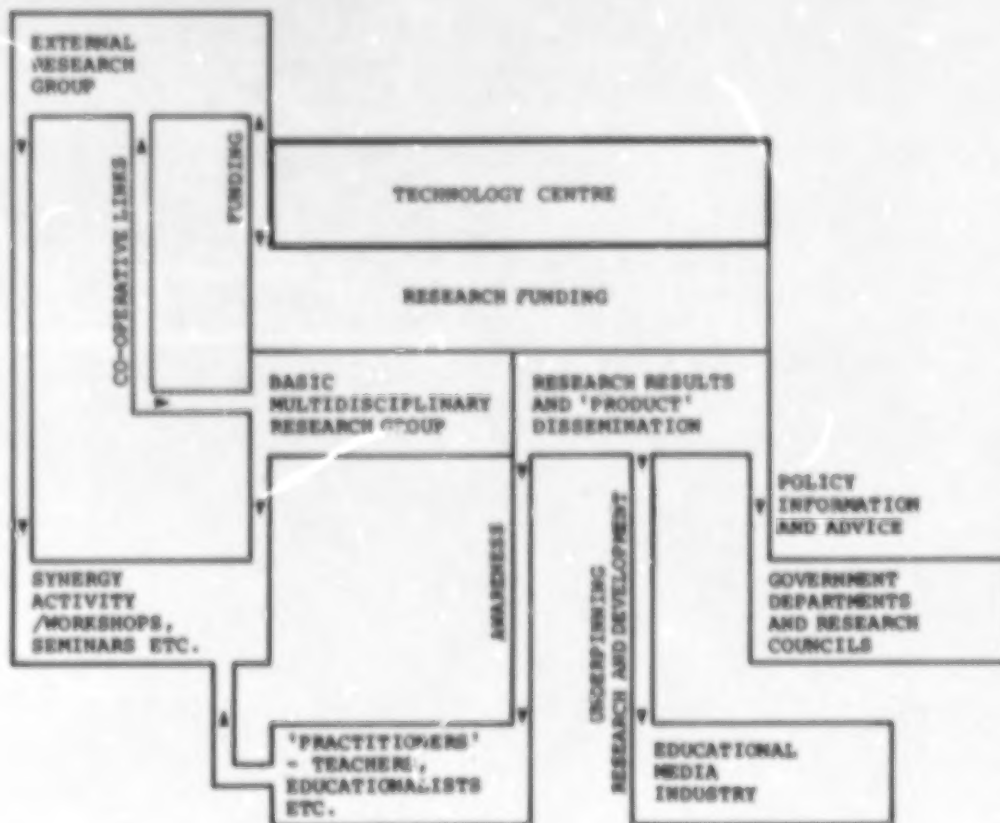


Figure 1 - Potential basic functions of a Technology Centre

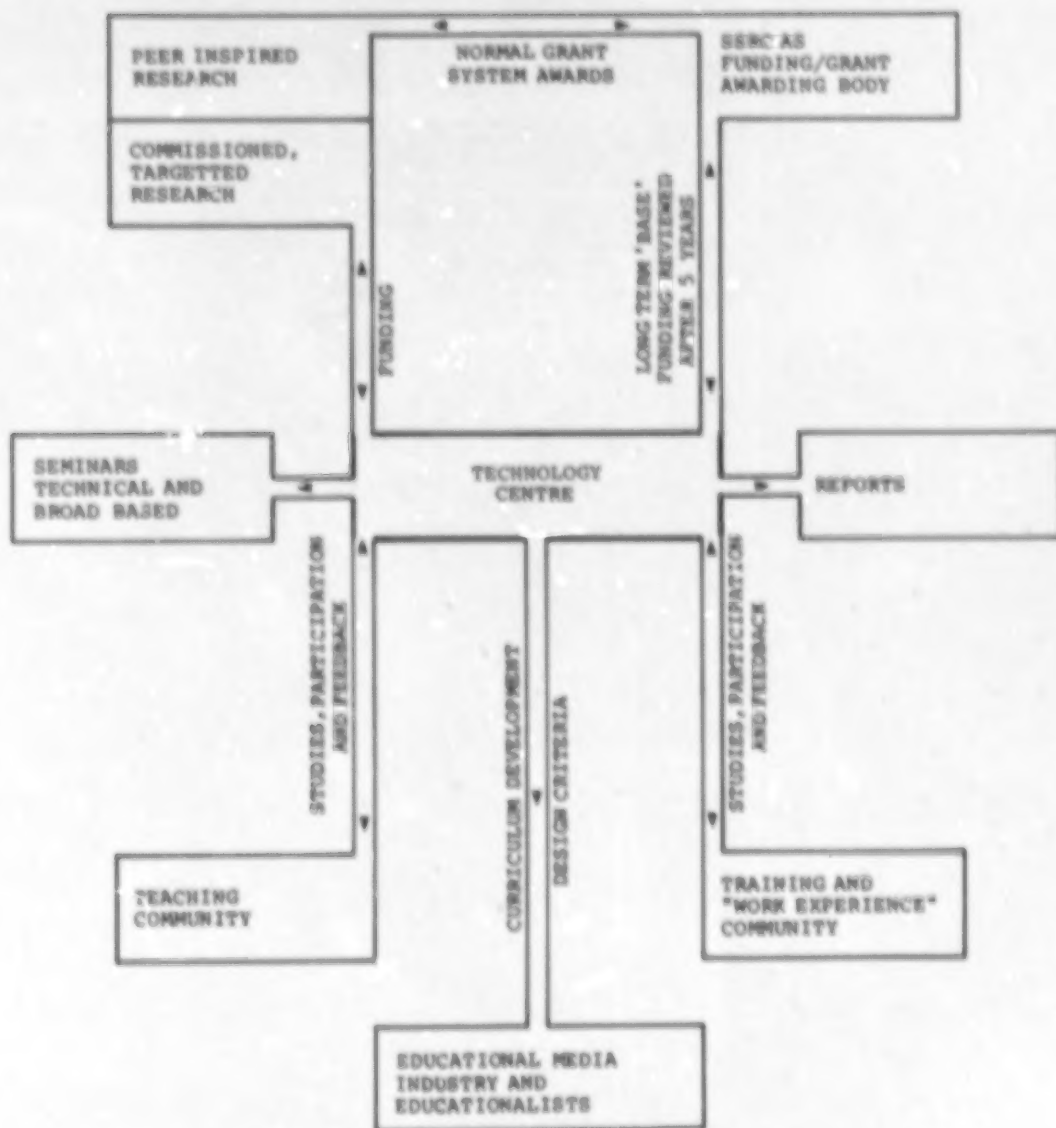


Figure 2 - Potential relationships of the Technology Centre - (showing SSRC as sole funding body for simplicity)

AREAS OF CONCERN:**Statements of Priority from within the Research Community and Other Interested Bodies**

- 1 In June 1982 we travelled to the USA and Canada. The purpose of this visit was to contact members of the relevant research communities, to observe developments at first hand and to discuss research progress and future plans. A report of this visit has been prepared separately
- 2 Since returning from overseas, we have visited or been visited by members of a number of British research groups and other formal and informal bodies involved or interested in this field. The information annexed to the Working Group's original report (q.v.) has been augmented with more up-to-date information regarding ideas and developments.
- 3 In the course of unstructured discussions, our colleagues were asked their opinions about those aspects of this field which merited research attention as a matter of priority. A large number of what we have designated "Areas of Concern" emerged, and they are listed later in this appendix. They are grouped for convenience under a number of headings, but neither the headings nor the order of listing is intended to imply any hierarchy of significance.
- 4 The extent of the variety of the topics listed reflect both the wide range of opinions canvassed and the diffuseness of research interests in this field. It is clear that not all of the areas are equally deserving of or appropriate to the attention of SSRC.

Whilst some of them represent discrete research problems of real significance, others are of relatively minor importance, and others still are so vaguely stated as to be of little value.

- 5 It appeared to us that two themes emerged from our discussions and can be discerned in the list of areas of concern:

1. 'Educational Technology' aspects of the computer

11. Curricular implications of new technologies

The first of these themes subsumes many crucially important problems, both technical and curricular, focussing on the perception of the microprocessor as a basis for versatile and powerful teaching aids. The second theme goes beyond this into realms of societal and economic concern. Both lines of thought are significant in the present context. They are not mutually exclusive, but represent differences of emphasis rather than distinct disciplines. Our decision to propose two programmes of research was based partly on consideration of these themes.

- 6 The list of areas of concern was compiled from ~~transcriptions~~ of our notes. ~~It is not claimed to represent a comprehensive and objective survey of opinions, and no doubt it lacks perspective due to the way in~~

which it was assembled. We can only state that we have found it a useful aid to our deliberations, and hope that it may similarly serve other workers.

7 Teaching and Learning Processes

- a. Epistemological consequences of early contact with computers.
- b. Implications for the development of teaching strategies of increasing 'computer sophistication' among teachers and pupils.
- c. Influence of computer use on teachers' behaviour and professional activities.
- d. Skills and personal attributes needed to learn with the aid of computers.
- e. Characteristics of individual/small group learning with computers.
- f. Learning processes in peer tutoring environments.
- g. Nature and extent of cognitive gains due to computer use, and the transfer of learning.
- h. Influence of computing environments on children's language development.
- i. Effects of computers on patterns of interaction and dialogue in the classroom.
- j. Pupil-teacher ratios in hardware-rich environments.
- k. Influence of computer use on children's metaphor, conceptualisation and personal construct.
- l. Investigative learning in computer environments.
- m. Theoretical models for computer-assisted teaching and learning.

8 Teacher Training

- a. Need and demand for basic "computer literacy".
- b. Follow-up and evaluation of MEP induction courses.
- c. Retraining needs of administrators and teacher educators.
- d. Impact on the school curriculum, colleague attitudes etc. of teachers who have attended training courses.
- e. Implications of computer competence for personal advancement and job security.

9 The Curriculum

- a. Database techniques and curriculum development.
- b. Identification of potential computer applications.

- c. Cultural and "hidden curriculum" impact of computer-rich out-of-school environments.
- d. Implications of the computer for specific subjects.
- e. Computers and industrial/vocational educators.
- f. "Computer literacy" effects of curricular use of computer applications.
- g. Computers in vocational guidance.
- h. Computers and the education/training interface.
- i. A curriculum model for the "information era".

10 **School Case Studies**

- a. Development of observation methodology.
- b. Observations in resource-rich and resource-poor schools.
- c. Case studies of CAE and CML applications.
- d. Longitudinal studies of teacher-led curriculum developments.
- e. Administrative use of computers.
- f. Reason for non-adoption of CAE by schools or individual teachers.

11 **Assessment and Evaluation**

- a. Development of CML techniques.
- b. The Rasch model and the microcomputer.
- c. Item banking with microcomputers.
- d. Computers in test production and analysis.

12 **Teaching and the Handicapped**

- a. Use of computer microworlds as teaching environments.
- b. Voice-directed computing for visually handicapped people.
- c. Computers and information technology in home-based learning.
- d. Use of computer games.
- e. Special purpose peripherals.
- f. Word-processing aids to 'writing' and their effects on acquisition and use of language.

13 **The School as a Social Organisation**

- a. "Solo-mode" computing and its effects on socialisation.
- b. Social characteristics of peer-tutoring environments.

- c. Computers and small-group interactions.
- d. Patterns of friendship and esteem in computer environments.
- e. Socioeconomic class factors in information richness and its counterpart.
- f. Discipline, organisation and control in the computer assisted learning environment.
- g. Computer use in pastoral systems.
- h. Allocation of resources to computing as a factor in staff stress and conflict.
- i. Changes in the role and status of the teacher.
- j. The role of parents in curriculum innovation: computer assisted education as a case in point.

14 Microcomputers and Mainframe Systems

- a. Analysis of future trends in hardware availability.
- b. Implication of potential new educational computing applications for patterns of hardware provision.
- c. An ideal model for hardware provision at local/national levels.

15 Software Design

- a. Means of stimulating software production.
- b. Implications of user cognitive style/preference for the design of software.
- c. Effects of program "personality" on learning and attitudes.
- d. Cognitive and affective effects of different programming languages on teachers and children.
- e. The effects of games and simulations.
- f. Structured programming and logical thinking skills.
- g. Design of interactive video courseware.
- h. Evaluation of specific software packages in classroom settings.
- i. Principles of screen layout and page design.
- j. The importance of colour in CAE materials.
- k. Low resolution graphics and inference from incomplete data.

16 Information Technology

- a. Educational implications of cable networks.

- b. Design for telesoftware.
- c. Information technology and software distribution systems.
- d. Classroom uses of teletex.
- e. Teletex and videotex in continuing education.
- f. Teletex, telesoftware and investigative learning.

17 School Computer Studies

- a. Teaching styles and classroom processes in computer studies.
- b. Children's motives for choosing to study the subject.
- c. Relative performance of boys and girls.
- d. Relation of computer studies to the "real world".
- e. Influence of computer studies across the curriculum.

18 Primary Education

- a. Computer language standards for primary education.
- b. Word processing in primary schools.
- c. Levels of resource provision.
- d. Optimum age for first contact with the computer.
- e. Database and query techniques with young children.
- f. Learning with programmable mobile devices (BIGTRAK, TURTLE).
- g. Longitudinal studies with LOGO.

19 Expert Systems

- a. Applications in educational psychology.
- b. Expert CHL/CAL systems.
- c. Objective test designers.
- d. Subject-based expert systems.
- e. Diagnostic systems for remedial education.

20 Spin-Off

- a. LOGO, SMALLTALK etc. as research tools per se.
- b. Refinement of educational research methodology.

A Glossary of Acronyms and Abbreviations

AI	Artificial Intelligence
AIT	Advanced Information Technology
AUCBE	Advisory Unit for Computer Based Education (Hertfordshire)
CAE	Computer Assisted Education
CAL	Computer Assisted Learning
CARE	Centre for Applied Research in Education (East Anglia)
CEDAR	Computers in Education as a Resource (Imperial College)
CET	Council for Educational Technology
CML	Computer Managed Learning
DES	Department of Education and Science
DoI	Department of Industry
IKBS	Intelligent Knowledge Based Systems
ISMEC	Independent Schools Microelectronics Centre
IT	Information Technology
IVD	Interactive Videodisk
MEDC	Microelectronics Education Development Centre (Scotland)
MEP	Microelectronics Education Programme (England and Wales)
MMI	Man Machine Interaction
NDPCAL	National Development Programme for Computer Assisted Learning
OUCALRG	Open University Computer Assisted Learning Research Group
RIC	Regional Information Centre (England and Wales)
SCAMP	Schools Computer Administration and Management Project (Scotland)
SERC	Science and Engineering Research Council
SMDP	Scottish Microelectronics Development Programme
SSRC	Social Science Research Council
VLSI	Very Large Scale Integration